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Inversion of PROSPECT+SAIL Model for Estimating Vegetation Parameters from Hyperspectral Measurements with Application to Drought-Induced Impacts Detection

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Abstract : The aim of this study was to follow the canopy reflectance patterns in response to soil water deficit and to detect trends of changes in biophysical and biochemical parameters of grass (Poa pratensis species). We used visual interpretation, imaging spectroscopy and radiative transfer model inversion to monitor the gradual manifestation of water stress effects in a laboratory setting. Plots of 21 cm x 14.5 cm surface area with Poa pratensis plants that formed a closed canopy were subjected to water stress for 50 days. In a regular weekly schedule, canopy reflectance was measured. In addition, Leaf Area Index (LAI), Chlorophyll (a+b) content (Cab) and Leaf Water Content (Cw) were measured at regular time intervals. The 1-D bidirectional canopy reflectance model SAIL, coupled with the leaf optical properties model PROSPECT, was inverted using hyperspectral measurements by means of an iterative optimization method to retrieve vegetation biophysical and biochemical parameters. The relationships between retrieved LAI, Cab, Cw, and Cs (Senescent material) with soil moisture content were established in two separated groups; stress and non-stressed. To differentiate the water stress condition from the non-stressed condition, a threshold was defined that was based on the laboratory produced Soil Water Characteristic (SWC) curve. All parameters retrieved by model inversion using canopy spectral data showed good correlation with soil water content in the water stress condition. These parameters co-varied with soil moisture content under the stress condition (Chl: R2= 0.91, Cw: R2= 0.97, Cs: R2= 0.88 and LAI: R2=0.48) at the canopy level. To validate the results, the relationship between vegetation parameters that were measured in the laboratory and soil moisture content was established. The results were totally in agreement with the modeling outputs and confirmed the results produced by radiative transfer model inversion and spectroscopy. Since water stress changes all parts of the spectrum, we concluded that analysis of the reflectance spectrum in the VIS-NIR-MIR region is a promising tool for monitoring water stress impacts on vegetation.

Keywords : hyperspectral remote sensing, model inversion, vegetation responses, water stress
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